Table showing the Occurrence of the + and − Rainfall Pulses in other Parts of the World.

	+ 1870.	− 1877.	+ 1882.	− 1886.	+ 1892.
Batavia	—	1876	1882	1883	(?)
Mauritius	—	1877	1882	1888	1892
Catherinenburg (Russia)	—	1877	abs.	1887–8	1892
Scotland	—	1877	—	—	1892
Copenhagen	1872–3	1877	1882	1888	1891
Adelaide	1870	1877	1883	1889	1892–3
Tiflis	1870	1878	1881	1886–90	1893
Archangel	1872	1878	1881–2	1887–8	1892
Brussels	—	1878	1882	1888	1892
Hobart Town	—	1878	1882	1887	1893
*Malabar	1871	1878	1882	1888	1892
Toronto	1870	1878	1883	1886	1893
Córdoba (Arg.)	—	1878	1883	1888	1892
Cape	—	1878	1883	1888	1892
Java	1872	1879	1882	—	1893
Barnaul (Russia)	1872	1879	1882–3	1887	1894
St. Petersburg	1871	1879	1883	1888–9	1893
Nile	1871	1879	1883–4	—	1893–5

* For comparison.

"On the Restoration of Co-ordinated Movements after Nerve Crossing, with Interchange of Function of the Cerebral Cortical Centres." By ROBERT KENNEDY, M.A., D.Sc., M.D., Assistant Surgeon to the Western Infirmary, Glasgow. Communicated by Professor MCKENDRICK, F.R.S. Received October 11,—Read November 22, 1900.

(Abstract.)

I.—*Experiments on Nerve Crossing.*

The experiments on nerve crossing were undertaken in order to ascertain whether, after division and cross union of the entire nerve supply of two antagonistic groups of muscles, the animal can regain the power of performing voluntary co-ordinated movements with the affected muscles, and also to ascertain the effects on the cerebral cortical centres affected by the crossing.

The object of this was to ascertain if the organism has the power to compensate for a change whereby nerve centres are brought into connection with peripheral endings, not by nature belonging to them.

The experiments were made on the right fore-limb of dogs, and

were five in number. The first four were of the same kind, and consisted in uniting the central segments of the divided musculo-cutaneous, median, and ulnar nerves to the peripheral segment of the divided musculo-spiral, and *vice versâ*. Thus the entire supply of the flexor muscles of the forearm was crossed with the entire supply of the extensor muscles. The musculo-cutaneous was included in the crossing, as it sends a communicating branch to the median at the elbow, which branch may contain efferent fibres to muscles.

The nerves were divided above but near the elbow joint, and the two points of union were therefore situated one on the outside and one on the inside of the limb, with a bulky muscle between them, which prevented any possibility of confluent reunion of all the divided ends.

One of the experiments (Exp. I) was a failure on account of the wound becoming septic, but in the remaining three (Exp. II, III, IV) the animals regained almost completely the power of making voluntary co-ordinated movements of the limb. Thus the leg was used constantly and perfectly in walking and running, and in performing such co-ordinated movements as giving the paw on request, using the paw to hold a bone while gnawing, &c. The recovery of function commenced about the 30th day after the operation, and was almost perfect from the 45th to the 90th day.

The physiological examination showed that the nerves which had been crossed had united as they had been placed without one point of union communicating with the other, and that the flexor muscles were thus entirely supplied by the musculo-spiral, and the extensor muscles entirely by the median, ulnar, and musculo-cutaneous.

In two of the experiments (Exp. II and III) the musculo-spiral stimulated above the seat of union gave flexion of the paw, and no movement in the extensor muscles, while stimulation of the central segments of the musculo-cutaneous, median, and ulnar gave extension of the paw, and no movement in the flexor muscles. Stimulated on the cerebral cortical centres of the sigmoid gyrus, it was found that on the left hemisphere the centre which normally gives on stimulation flexion of the paw, gave on the contrary extension, and no movement whatever in the flexor muscles. Stimulation of the centre, normally associated with extension of the paw, gave in one of the animals pure flexion of the paw and no contractions of the extensor muscles (Exp. III), while in the other animal the flexion centre was found to lie in the normal extension area, but pure flexion could not be obtained free from extension movements (Exp. II).

In the other experiment (Exp. IV) the results of stimulation were somewhat obscure. Stimulation of the central segments of all four nerves gave contractions in the extensor muscles and no contractions in the flexors. Yet the flexors were perfectly healthy in appearance and possessed normal irritability to faradic stimuli. Stimulation of

the centres on the left sigmoid gyrus showed that the flexion centre had become an extension centre, but no flexion centre could be discovered.

In these experiments (II, III, IV) the centres on the right side of the brain were normally placed.

In all the experiments the irritability of the centres on the left side of the brain was increased rather than diminished.

In addition to these experiments on nerve crossing, there was also an experiment made on a dog to ascertain if the fact of crossing the nerves delayed the functional recovery beyond what would be expected merely as a result of nerve section. In this experiment the same nerves were divided, but were immediately reunited as accurately as possible. The result was that the course of recovery of function was not materially different from the course in the experiments on nerve crossing.

The physiological examination showed that the nerves had united well, and regained their normal irritability and conductivity, and that the muscles of the limb were healthy. Examination of the cerebral cortical centres showed that they were not well defined, but neither were they on the sound side in this animal.

II.—*Junction of the Peripheral Segment of the Divided Facial Nerve with the Trunk of the Spinal Accessory Nerve for the Treatment of Facial Spasm in a Woman.*

The experiments on dogs having shown that nerve crossing was followed by recovery of co-ordinated function, the following operation was undertaken for the treatment of facial spasm in a woman. Faure and Furet had already suggested utilising the branch of the spinal accessory to the trapezius for the supply of the face in the case of paralysis of the facial nerve, and Faure* had put the operation in practice, but without success. In the following case the patient had suffered for ten years. The right side of the face was incessantly twitching, the angle of the mouth being permanently drawn up, and the eyelids half closed. The condition had been under treatment at different periods, but without any success. Rather the condition got worse.

On May 4, 1899, the facial nerve was divided close to its exit from the aqueduct of Fallopius, and grafted on to the trunk of the spinal accessory, just as the latter nerve emerges from under the posterior belly of the digastric muscle. The digastric situated between the central end of the facial nerve and the junction with the spinal accessory prevented any reunion of the nerve.

Immediately after the operation, the right side of the face was in a condition of complete paralysis, and it remained in this condition for

* Faure, "Traitement Chirurgical de la Paralysie Faciale par l'Anastomose Spino-faciale," 'Revue de Chirurgie,' vol. 18 (1898), p. 1098.

some time, the muscles losing their faradic irritability. In course of time gradual improvement showed itself, heralded first by recovery of faradic irritability in the muscles. The earliest indications of improvement were shown in the orbicularis palpebrarum, which began to recover faradic irritability and movement, thereby enabling the eye to be slightly closed, about the 18th day. The movement of the muscle on stimulation with the faradic current was, however, so slight, that there was a possibility of error, and the slight voluntary movement might have been due simply to the relaxation of the levator palpebræ. By the 49th day, however, there was no doubt, as the contractions to faradic stimulations were well marked, and the palpebral fissure could be voluntarily closed one-half.

By the 141st day the faradic irritability of the other muscles began to be recovered, and by the 155th day the faradic current gave, on applying the electrode over the junction between facial and spinal accessory, strong contractions in all the muscles of the face.

Improvement gradually continued, and on August 17, 1900, about fifteen months after the operation, the condition was as follows: She experienced no difficulty on account of the condition of the face. There was no return of the spasmodic condition. The conjunctiva of the right eye was quite normal; there was no increased lachrymal secretion, and she never was troubled with dust getting into the eye, as winking was perfectly efficient. She could shut the eye completely, although not so tightly as in the case of the sound eye. The orbicularis palpebrarum also contracted well to reflex stimuli. The right side of the brow could be wrinkled to a very slight degree only, and movements could be made in the cheek and mouth, although they could not well be co-ordinated. The labial letters could be perfectly pronounced, and the buccinator was efficient to prevent accumulation of food between cheek and gums while eating.

There was no atrophy of the side of the face, and in repose there was no appearance of facial paralysis, the muscles having regained their tonus, and the normal sulci being well marked.

There was evidence of want of power over the face in the difficulty of raising the eyebrow, or of making a circular aperture with the mouth in whistling or blowing. The muscles, however, of these parts were perfectly sound, as the faradic current gave perfectly normal reactions, both when applied directly to the muscles and when applied to the motor point of the nerve. This motor point lay about 2 cm. lower down than normally, *i.e.*, over the junction of the facial and spinal accessory.

The reactions and movements of the trapezius and of the sterno-mastoid were normal.

A curious effect resulted when the arm was suddenly thrown up; for the face at the same time was thrown into contractions, owing to

the impulses intended for the trapezius being directed to the face. If the arm was continued held up, these contractions of the face passed off.

III.—*General Conclusions.*

1. In the fore-limb of the dog, the nerve supply of the flexor muscles may be crossed with that of the extensor muscles, with the result that, despite the altered innervation, the animal regains, as before, the power of performing voluntary co-ordinated movements of the limb.

2. The fact of crossing the nerves does not add materially to the time which would be required for recovery of function of the limb if the same nerves were simply divided and reunited by suture as accurately as possible.

3. The result of crossing the nerve supply of antagonistic groups of muscles is that the nerve centres which formerly innervated the one group now serve for the other group, and this alteration extends to the cerebral cortical centres, which become interchanged in position and retain their irritability.

4. The cerebral cortical centres which have been made to interchange their positions by the crossing, are able, in response to the will, to emit impulses which can call forth in the new peripheral terminations movements in perfect co-ordination.

5. In man the facial nerve may be detached from the facial centre, attached to the spinal accessory nerve, and the facial muscles thus innervated by the spinal accessory centre, with the result that co-ordinated movements of the face, both voluntary and reflex, are at least in part restored.

6. In the case of reunion of a divided nerve, it is not necessary to suppose that regeneration restores the old paths for the nervous impulses, since, if new paths are formed by the imperfect co-adaptation of the divided nerve ends, with the result of altering the connections between central nerve cells and peripheral endings, the organism has the power of compensating this alteration.

7. In the case of paralysis of a muscle or group of muscles, if the nerve supplying the affected muscle or muscles is grafted on to a neighbouring efferent nerve supplying muscles which are healthy, it is probable that the affected muscle or group of muscles, if not already destroyed by degenerative process, will regain its normal function.